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Published in:
Nuclear Physics B

DOI:
10.1016/j.nuclphysbps.2012.09.165

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Nuclear Physics B (Proc. Suppl.) 229–232 (2012) 528

NUCLEAR PHYSICS B PROCEEDINGS SUPPLEMENTS

www.elsevier.com/locate/npbps

Improved Scintillator Materials For Compact Electron Antineutrino Detectors

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Abstract

Recent developments provide new components holding the potential to improve the performance of liquid scintillation electron antineutrino detectors used as nuclear reactors monitors. Current systems raise issues regarding size, quantum efficiency, stability, and spatial resolution of the vertex detection. For compact detectors (1 m^3 active volume) improving these issues is possible by developing stable and efficient boron or lithium containing NCA. In addition, advances in fluorescence detection technologies and optimization of solvent characteristics can improve the overall efficiency. Focus points of material design are to enable a compact, robust, and direction sensitive detector.

Keywords: Electron antineutrino detection, liquid scintillators

Advances in chemistry, materials science and electronics open possibilities to improve current electron antineutrino detectors design. Our main interest at present is improving neutron capture agents (NCA), fluorescent dopants and solvent. Further areas of interest lie in the field of photon detection and signal processing which will be addressed in the future.

Until recently, the NCAs employed were mostly unstable compounds.[1] These systems needed constant purification, monitoring, and calibration. Recently it was shown that *beta*-diketone Gd compounds improved the overall stability of the system.[2] However those Gd systems form opaque plastics when mixed with polymers and are thus not suitable as a solid and safe detector medium.[3] The advantage of boron and lithium as NCA is that the alpha particles produced deposit their energy to the solvent close to the point of neutron capture thereby retaining directional sensitivity. The unstable compound $B(OMe)_3$, has in small scale tests, been used successfully as an NCA.[4] By improving the design of the coordinating ligands surrounding the boron or lithium atom, compounds with improved attenuation lengths, stability and solubility should be obtainable.

Fluorescent compounds and wavelength shifters used currently are based on systems available at the beginning of scintillation counting.[5] In recent years new technologies including solar cells, OLEDS and Q-dots have provided new fluorescent materials which may also be of interest for scintillation purposes.[6, 7, 8] These compounds have been developed with cost, durability and quantum efficiency in mind and are the state of the art in fluorescence technology. The emission wavelengths of these substances are easy to tune, and thus provide the means to match optimally the emission wavelength to the absorption band of the photon detector. At present, we are in the process of identifying compounds, which are most suited for use in antineutrino detectors.

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☆INCAS3 is made possible by the support of: The Northern Netherlands Provinces (SNN). This project is co-financed by the European Union, European Fund for Regional Development and the Ministry of Economic Affairs, Peaks in the Delta.

doi:10.1016/j.nuclphysbps.2012.09.165